APIs, the glue under the hood. Looking for the “API economy”

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Jean paul Simon
Google Inc.

APIs, the glue under the hood. Looking for the "API economy"

Jean Paul Simon

Jean Paul Simon is based at JPS Public Policy Consulting, Seville, Spain.

Abstract

Purpose – *Some specialized consultancies have been making the case of an "API economy". This study aims to investigate the issue, marshalling data on the economic dimension, to better understand the environments of APIs. It offers an overview of the functions and definition of application programming interfaces (APIs) in the backdrop of the history of services computing. The paper attempt assessing the economic value (size of the market) of APIs and reviews some of the available metrics. The paper also takes a look some issues and challenges ahead for the deployment of all kind of APIs.*

Design/methodology/approach – *The paper is based on desk research and a scientific and grey literature review. However, it relies mostly on specialized consultancies although from a critical viewpoint. The paper provides an historical account of the notions of APIs and API economy.*

Findings – *The paper questions the idea of an "API economy" that still stands on the "hype" side and is not clearly substantiated. It reveals that the number of firms with mature API programs remains small and that there is an uneven development across industries (traditional firms are less active than digital natives) and countries (Silicon Valley is leading). It highlights that the domination of IT companies (leaders and pioneers of APIs) raises issue of competition and at some point, may prevent rather than foster innovation.*

Research limitations/implications – *There is no robust data about the size of the API market nor about its value. Sources are highly heterogeneous and delimitations not always precise. The standard metrics or indicators are hard to find. Further research would be needed to better document this area.*

Practical implications – *The paper reviews some of the expected benefits of the use of APIs as enablers of private or public ecosystems.*

Social implications – *The paper delineates some of the economic benefits of the public APIs based on open data. It shows some positive examples of public APIs in the EU.*

Originality/value – *There is hardly any mention of the API economy in research literature. Most of the academic literature still stems from engineering department or business-management departments, not department of economics. Consultants would usually focus on the potential of business growth, on how to design an effective API strategy but not on the very economic dimension. The paper attempts providing a synthesis of the available data.*

Keywords *Open systems, Technology led strategy, Innovation, Economics, Computer software, Computer applications*

Paper type *Case study*

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This paper is based on a research for the Digital Economy Unit of the EC JRC, for the APIs4DGov project launched with the purpose to gain further understanding of the current use of APIs in digital government and their added value for public services (see Vaccari et al, 2020, and Box 2). The views expressed are purely those of the author.

1. Introduction

The issue of the "API economy" has been triggering some hype recently, but remains somehow under the radar as the issue is both highly technical and at the same time the functions of an API are rather hidden, remaining "*under the hood*" (MuleSoft, 2018a). Some of specialized consultancies have been making the case of an "API economy". The aim of this article is to investigate the issue, marshalling data on the economic dimension, to better understand the environments of APIs.

An API (Application Programming Interface) is an "interface that is defined in terms of a set of functions and procedures, and enables a program to gain access to facilities within an

application[1].” Simply put, an API is an interface that allows software to interact with other software. This is part of its name – API, Application Programming Interface – and is core to its functionality. APIs are held allowing an existing or new business capability available from across a network as an on-demand service for usage by other applications and software. MuleSoft (2019a, 2019b: p. 15) claims that “APIs are the glue that connect the digital world.”

APIs are not new[2] as companies such as Salesforce and eBay first allowed access to their Web APIs almost 20 years ago, in 2000. The past few years, however, have seen a strong growth and the API space is evolving more rapidly than ever before. This space now also includes digital government APIs or public APIs[3]. Broadly speaking, an API strategy is meant to help an entity to develop quickly, improve internal efficiencies and better collaborate with partners.

The paper is based on desk research and a scientific and grey literature review. It relies mostly on specialized consultancies although from a critical viewpoint. It attempts to track some of the key properties of APIs, to explore the essential cooperative dimension of API, so as to flesh out the kind of relationships between players. It looks at their role in the digital transformation, attempts to assess its economic impact and shed new perspectives on the API economy.

The paper is divided into three parts. The first part offers an overview of this new domain, it looks briefly into some private ecosystems, analysing the different API strategies of its players. It introduces some examples of public/government APIs and ends with a presentation of the global geography of APIs.

The second section investigates the economic value (size of the market) of APIs and reviews the main benefits to be expected from APIs as enablers of ecosystems. The third section question the idea of an “API economy” and takes a look at some of the criticisms. The paper concludes calling for some caution and summing up some of the challenges ahead.

2. Application programming interfaces, a brave new world?

APIs are tools that allow businesses to unlock the value of internal data, making it easy for people to consume data and applications in a standardized way. API is a technical solution to boost the potential of data, as tools that allow businesses to unlock the value of internal data, making it easy for people to consume data and applications in a standardized way.

One can sum up the main APIs key properties in the following fashion:

- Reusability and substitution: ecosystem facilitators;
- Single access point: provides capabilities to monitor usage and therefore estimate demand; and
- And modularity.

As indicated by the ProgrammableWeb Directory, since 2005, APIs grew “from a curiosity to a trend, and now to the point where APIs are core to many businesses,” to more than 22,000 entries in 2019[4], 10 times the amount listed in 2010. At the same time, instead of remaining just a strategic offshoot for existing technologies, APIs have transformed into “as a service” variants: Software-as-a-Service (SaaS), Platform-as-a-service (PaaS) (Doerrfeld, 2016). As noted by Moilanen *et al.* (2019: p. 11): “Exploiting the APIs of external organizations – often those outside of typical partnerships – in the development of a service contributes to the transformation of companies into ecosystems, because interdependencies are created between organizations.” Combining APIs may improve the ecosystems and enable innovation.

2.1 Building an "architecture of participation"

Tan *et al.* (2016: p. 65) give an account of the history of services computing. After debuting in the early 2000s, services computing has transitioned from an enterprise interoperation technology to shape the Web API economy. The authors claim that Web services, particularly Web APIs, are becoming the backbone of Web, cloud, mobile and machine learning applications (Figure 1).

Or to follow Huhtamäki *et al.* (2017), APIs helped transforming "the Web from a page-centric collection of documents to an "architecture of participation" in which users create and share data with the help of a network of Web applications and communication with each other through APIs." Therefore, they deem APIs as the true building blocks of digital transformation. Hatvala (2016: p. 19) distinguishes three types of strategies for the deployment of APIs: private, partner and public [5] (Figure 2). Private APIs are internal tools of integration, rationalizing infrastructure and reducing costs. Partners APIs facilitate communication and the integration of software between parties, creating value-added services. Public APIs enable public exposure of data and functionalities to third parties [6].

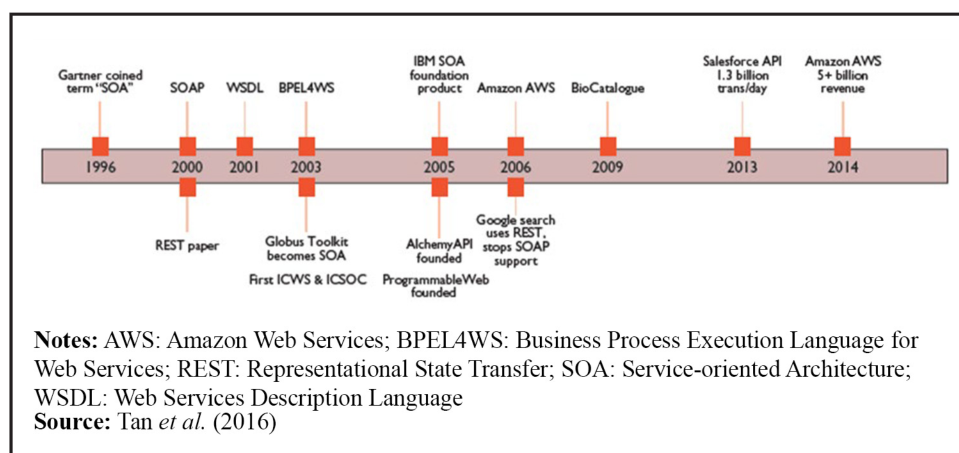
There is, some consensus in the technical literature, about the essential cooperative dimension of APIs, "tapping into the power of communities": "APIs are the vehicle that connects a product or service" to massive new communities (Medrano, 2012). "Communities" seem to be another name for "ecosystem" in the literature. Iyer and Subramaniam (2015a) give the example of Twilio [7], a company that focuses on the communities that drive adoption of its APIs: Twilio opened its APIs and allowed third-party developers to use them. It is now used as the "communication engine" for Uber, Airbnb, Home Depot, Walmart and others.

2.2 Growing private ecosystems, opened and closed: looking at a sample

Gartner (2018) describes the management of APIs as: "the planning, design, implementation, testing, publication, operation, consumption, maintenance, versioning and retirement of APIs." The consultancy adds that "it involves use of a developers' portal to target, market to and govern communities of developers who embed the APIs, as well as runtime management, estimation of API value and analytics." In other words: fleshing out the relationships with other players and building the relevant ecosystem.

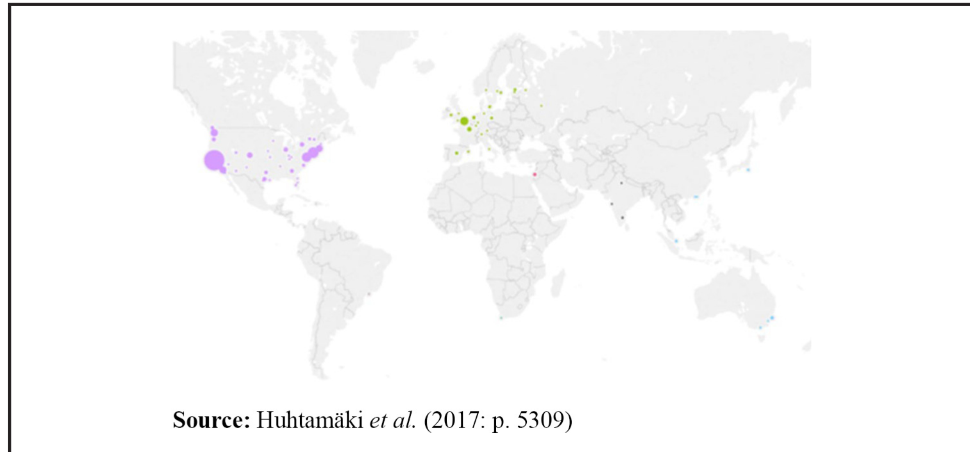
Some leading companies in the field such as Amazon, Apple, Facebook or Google (but also Chinese IT companies such as Alibaba, Baidu and Tencent) have been constructing their own ecosystems (in the broader sense) over the past decade, one could further investigate

Figure 1 A brief history of services computing



Notes: AWS: Amazon Web Services; BPEL4WS: Business Process Execution Language for Web Services; REST: Representational State Transfer; SOA: Service-oriented Architecture; WSDL: Web Services Description Language
Source: Tan *et al.* (2016)

Figure 2 The global distribution of API availability (2017)



Source: Huhtamäki *et al.* (2017: p. 5309)

the way these companies have structured their environment (contractual relationships with developers). As noted by Benzell *et al.* (2017: p. 3), quoting Amazon, eBay and Salesforce.com: "many web-pioneers featured APIs as core to their business."

We focus on a non-representative sample[8] of some of these leading digital natives. One can note that they are API driven and provide, one way or another, services to other third parties, mostly developers. In some cases, they may receive a fee for some of the services they provide (see Box 3 for the business models), especially for granting access to their payment infrastructure (Alibaba, Apple, Amazon, Facebook) or for other services such as cloud services (Alibaba's Aliyun, Amazon's AWS, Google's Big Query), content delivery networks (Alibaba, Amazon) and can offer tailored advertising services[9]. However, this is not the core of their business models, as it brings an insignificant, although variable, stream of revenues.

These firms have different strategies such as the ones identified by Hatvalla or a combination of these strategies. For Facebook, as of 2011, revenues derived from its commercial relationships with the game company Zynga (publisher of world hits such as "Farmville") were around 15% (De Prato and Simon, 2015), but it has been decreasing as to become almost unnoticeable. Apple is a hardware company selling all kind of devices but not relying on revenues from the monetization of content (music, news, video, videogames…) that accounted for less of 1% of its gross profits as the creation of the AppStore (Simon, 2016a). Content and apps are a way to lure in customers but revenues are not significant. Besides, the Apple ecosystem is a closed one designed to lock in the customers, to keep them buying high-margin devices. This makes sense from a manufacturer viewpoint and triggers exclusivity arrangements with third parties. By contrast, companies with a core business model built on generating advertising revenues (Baidu, Facebook and Google) can leave their ecosystems (more) open and rely on open sources. Facebook is typically "device and software agnostic," delivering SDK[10] for iOS, Android and Unity. As noted by Jung and Lee (2010), an "Open API" strategy transformed Facebook one-to-one communication network into a group forming network. Amazon is quoted as "master of that thriving ecosystem; one that routinely leverages a networkable software interface known as the API or application programming interface as its means to that end" (MuleSoft, 2018a, 2018c).

The core of the strategy to generate the expected stream of revenues, be it sales of hardware (Apple), products (Alibaba, Amazon), virtual items (Tencent) or advertising revenues (Baidu, Facebook and Google) is to grow the market boosting the dynamics of all the parties involved in each specific ecosystem, accruing its value. Eventually, as illustrated

by the case of Facebook, the transition to "Open Api" increased potential connectivity in social network and led to exponential growth of social network adoption. Jung and Lee (2010) highlighted that Facebook 'use of Open APIs "led to a radical increase in user growth of Facebook and threatened Myspace, which was the top SNS at that time[11]." The relationship between the private companies and developers does not stop at the mere provision of SDKs but involves some forms of community building, for instance, through the annual developer conference (Apple, Facebook, Google…). Salesforce acquired MuleSoft a specialized entity that also provides courses and training and webinars[12].

In any case, as noted by MuleSoft (2018b: p. 48): "choices, costs and savings will be different from one organization to the next depending on the aspirations and breadth of the intended ecosystems (reflected of course, in the digital strategy) and the extent of renovation and transformation."

2.3 Going public? A twofold approach

The same consulting firm adds to further differentiate strategies from different entities: "For example, the engagement expenses involved in a public API economy offering are very different from that of a private offering that stays within the corporate firewalls or that is only offered to partners." According to Gartner (2018: p. 22): "APIs have become synonymous with facilitating the opening of large data sources to citizens and other third parties."

Developing an API, is one way to provide easier access to open data. This provides citizens with an easy-to-use, informative and engaging way to view data that was once inaccessible. Open Data policies following the 2010 Digital Agenda for Europe (Box 1 and Box 2) and the USA Open Government Directive of 2009 have been adopted. In the wake of these Open Data policies several Asian Governments (Hong Kong, India, Singapore[13], South Korea and Taiwan) did set up open data portals. At the city level, these apps are, for instance, helping citizens pay for parking spots or map public services such as parks and restrooms (Picard and Chang, 2014). In the specific case of India, the Open Government Data Platform is a single-point of access to public APIs such as "Real time Air Quality Index from various location" or "Current Daily Price of Various Commodities from Various Markets."

Box 1: Public sector information (PSI)[14], open data and public APIs, European Policies.

In 2003, the European Commission set up a legal framework to allow the re-use of PSI through the "PSI Directive" (Directive 2003/98/EC) revised by Directive 2013/37/EU. It focuses on the economic aspects of the re-use of information. In 2009, the European Commission recognized that PSI was the single largest source of information in Europe and the potential for re-use of PSI needed to be highlighted in the digital age. From that angle, APIs appeared to be a relevant tool to implement some of these evolving goals.

In 2017, after a public online consultation on the review of Directive, a proposal for a revision of the Directive was adopted by the European Commission on April 2018. The new Directive (EU) 2019/1024 on open data and the re-use of PSI was adopted and published on 20 June 2019 and is to be implemented by Member States by 16 July 2021.

It builds on the assumption that the public entities possess data that are highly valuable for stakeholders in the data economy (e.g. real-time data on buses routes and trains) and based on which a number of added value services and applications could be provided. The goals to further make public sector and publicly funded data re-usable, combine economic ("stimulate economic growth and spur innovation"), social ("address societal challenges") and political parameters ("foster the participation of citizens/increase the transparency of government").

The Interoperability Solutions for European Public Administrations (ISA^2) Program supports the development of digital solutions that enable public administrations, businesses and citizens in Europe to benefit from interoperable cross-border and cross-sector public services.

Source: Welle Donker (2016), EC.

The Garner report[15] (2018: p. 26) provides an overview of the size of the population of public APIs within the EU. The report concentrates on a sample of seven cases[16]. It addresses the costs and the benefits of the APIs implemented in the seven case studies. The panorama of these public APIs looks diverse with most of the APIs providing access to open data sources for developers to use to create applications for commercial sale and others having more democracy/citizenship-based aims. This means that the main goals are twofold: one economic goal of enabling the creation of innovative APIs building on public data and one more citizen driven. On the citizen side the improvement of access, better quality information and some cost reductions may be perceived as the main drivers. Basically, in all the case studies commercial partners/developers are free to build on the public data provided, adding their own data to produce value.

To illustrate the economic stimulation public APIs can bring, the Gartner report adds the example of Transport for London's policy. The example reveals some commercial relationships and partnerships with private companies such as Apple, Twitter and Waze (Gartner, 2018: p. 24): The report claims that by allowing the data to be available via the Open Government License has led to the creation of additional economic activity in the order of £100m of direct value and has enabled some 1,000 jobs.

The EC 2017 assessment study [European Commission (EC), 2017a, 2017b, 2017c: p. 255] gives another example of this positive process through the example of the French National Address Register (BAN)[17] described as "revolutionizing its Address Register through APIs." As the launch of the project, there has been a dramatic increase of data re-use in particular from the public geocoding API[18], with more than 1 billion hits in 2017 against 440 million hits in 2016 and 5,000 downloads of the whole territory. Among the main re-users of the geocoding API are French eCommerce websites and supermarkets.

Building on these previous works the European Commission APIs4DGov study[19] gives a comprehensive overview of the "Government application programming interface cases" in the EU. The study notes that "government APIs in the European Union are still in an initial stage (i.e. the number of cases is relatively low)" (Vaccari *et al.*, 2020: p. 48). The APIs landscape "is still scarce and uneven" (Vaccari *et al.*, p. 43).

Box 2. *Application Programming Interfaces in Governments: Why, what and how*. The European Commission APIs4DGov study.

The report explains how APIs support digital governments and help create new public services, new delivery models and new service delivery channels, aiming to better serve citizens and enable new business models to be developed. The work aims to improve the understanding of the current use of APIs in digital government and their added value and to assess the feasibility of establishing a European API framework for digital government. In short, it attempts to answer two questions.

1. Why should governments invest in the adoption of APIs?

2. How should they do?

The research, analysis and results of the study were meant to contribute to specific EU digital government policy documents and initiatives. Indeed, the European

Commission has produced a series of policy instruments that require or suggest the adoption of APIs in governments and in some specific areas in particular:

– The *Open Data Directive* (European Union, 2019), which specifically requires the mandatory use of APIs for "high-value" and dynamic data sets as "conditions for [their] reuse";

– The communication *A European Strategy for Data* [European Commission (EC), 2020a, 2020b], which reports on the future investment in "the establishment of EU-wide common, interoperable data spaces";

– the communication *Towards a Common European Data Space* [European Commission (EC), 2018] which, in terms of business-to-business (B2B) data sharing, reports that "there is strong support from stakeholders for non-regulatory measures, such as fostering the use of APIs for simpler and more automated access to and use of datasets";

– The *EU e-government action plan* 2016–2020 [European Commission (EC), 2016];

– The implementation of the *European interoperability framework* (EIF) [European Commission (EC), 2017a, 2017b, 2017c];

– The *implementation of the "once-only" principle* (OOP) [European Commission (EC), 2017a, 2017b, 2017c];

– The "building block" approach adopted in the *Connecting Europe Facility* (CEF) telecommunications program [European Commission (EC), 2020a, 2020b].

Source: compiled by author from Vaccari *et al.* (2020: p. 16, 22),

Moilanen *et al.* (2019: p. 85), picking up the example of the Finnish Meteorological Institute that provides weather information via an API, delineates some of the economic benefits of such weather data. It can help saving energy in building for heating or optimize traffic. Weather data provides valuable information that can be supplied by many commercial operators.

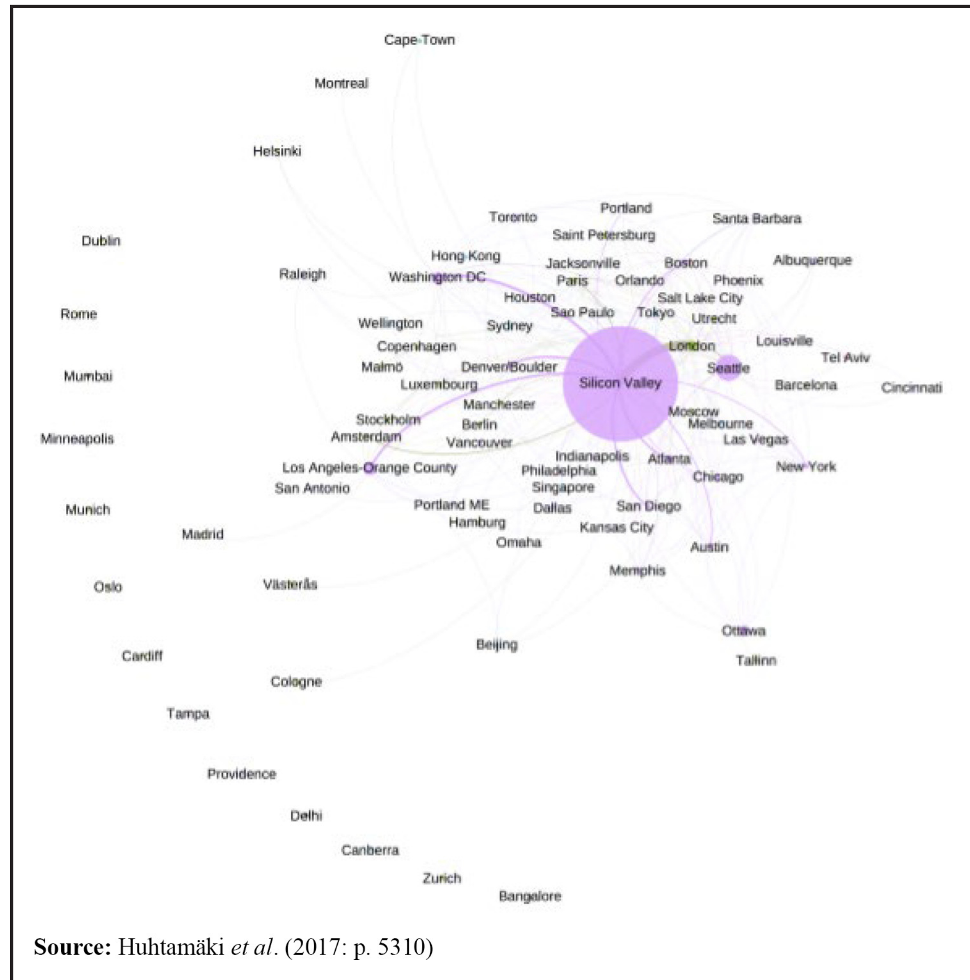
2.4 The geography of application programming interfaces availability

The analysis of the geographical distribution of API availability (classified according to the number of APIs available in a particular location: see Figure 2) yields some interesting results, although not surprising (Huhtamäki *et al.*, 2017): Silicon Valley leads the field with 1,623 APIs and Europe as an aggregate is providing fewer APIs and mashups than California alone (London is the leading region in terms of API availability with 271 APIs).

The authors suggest that innovation with APIs requires a deep understanding and fine-tuning of code, and that, "a shared context is absolutely vital"." The co-location of development efforts has major advantages in this context setting and fine-tuning phases of development. This may have some important impact on the production and sharing of public APIs. If cities such as Amsterdam, Berlin, Copenhagen, Cologne, Hamburg, London, Paris or Madrid are present in the Figure 3 (based on how the individual regions are connected through API co-use), other European regions may be at competitive disadvantage. Weiss and Gangadharan (2010), also using visual analytics, already showed that "the growth of the mashup ecosystem follows a pattern where keystone data providers or 'powerful hubs' attract niche data providers as complementors," and that the positions of keystones in the ecosystem are mutually reinforcing.

Evans and Basole (2015) complements these views[20] with another application of visual analytics[21], showing that the API economy is dominated by relatively young digital

Figure 3 API co-use between entrepreneurial regions (2017)



Source: Huhtamäki *et al*. (2017: p. 5310)

platform companies. Few traditional firms are active in the open API economy. Most central to this emerging ecosystem are companies that have built businesses around areas such as social, mapping, search, on-line payment, image sharing, video and messaging. They include well-known companies such as Google, Microsoft, Facebook, Amazon, eBay, Yahoo, Salesforce and Twilio and lesser-known companies such as Quova, Anedot and Zapier. These companies, such as Twilio, can play a major role within their own niche.

3. Gauging the application programming interfaces market

One should stress that there is no robust data neither about the size of the API market nor about its value. Sources are highly heterogeneous and delimitations not always precise. Nevertheless, one can find some partial elements about these aspects. For instance, according to a MuleSoft's Connectivity Benchmark Report (Pearlman, 2016,) 50% of large companies (10,000 employees or more) are making more than 10 million dollars in annual revenue from APIs. As of 2013, Musser (2013) described API as a 1 billion business. Besides APIs are deem having a major multiplier effect and can be seen as "the glue of software as service" (SaaS) (Musser, 2013). In other words, APIs are supposed to have positive externalities. However, as with any externalities, from an economic viewpoint,

measurement is always an issue. For instance, the use of multipliers is a particularly contested area of economic impact assessment.

Gartner (2018) estimated that the API market amounted to $961.2m in 2017 and expected it to top $1bn in 2018 and a 2016-to-2021 compound annual growth rate of 14.9%, with most of the current growth coming from cloud solutions. Another consultancy, Markets and Markets (2020), gave a similar amount for 2018 and predicted the market to grow to $5.1bn dollars by 2023.

3.1 The role of application programming interfacess within an ecosystem: unlocking the value of data

The consulting firm MuleSoft (2018a, 2018c) defines APIs as “the tools that allow businesses to put that data to use — by inspiring innovative developers to create new business opportunities and improve existing products, systems, and operations.”

Boyd (2015) highlights API as a technical asset necessary to build out an ecosystem, with APIs at the heart of a “distribution-centric” platform model. According to him, “in a distribution-centric API platform, value is first generated by turning things into data assets.” He gives the example of Spotify to illustrate how the Swedish music streaming service has achieved this by turning music into data. Indeed, he indicates that APIs were at the heart of the acquisition plan of the firm The Echo Nest for $100m in 2014. Netflix is another example of such a reliance on APIs (Art, 2016)

By the same token, MuleSoft highlights the role of APIs within an ecosystem: “API technology is invariably under the hood keeping their ecosystems glued together, while also serving as business channel and business model multiplexers” (Mulesoft, 2018a, 2018c). The same company states “that more and more organizations are starting to realize the benefits of having an API strategy and the financial benefits it can bring” (Mulesoft, 2018b). Box 3 reviews the main common business models[22] for API exposure.

APIs allow firms to expand into markets they may never have previously considered. Doerrfeld (2016) deemed that APIs allowed “new business ventures never before possible,” and identified 10 “new breeds of companies” that quite literally owe their existence to the emergence of the world of APIs. Payne (2015) considered that rise of APIs has been creating a new genre of marketing[23], called B2D or “business to developers” i.e. “an indirect approach for companies marketing their business to developers is helping them reach a wider audience – in particular through providing educational or informative resources.”

Box 3. Common business models for APIs.

Free APIs:

Available for consumption at no charge such as the APIs for popular social networks. Free APIs can drive adoption of APIs and brand loyalty and allowing the API provider to enter new channels. While there is usually no direct business benefit gained from exposing free APIs the majority of examples do have an indirect business benefit:

– Indirect: this business does not include direct monetary exchange; however, the API providers benefit significantly from exposing these types of API by generating revenue in other ways (advertising, services. . .).

Developer pays:

– Pay as you go: Pricing is determined by metered usage.

– Tiered: Developers sign up to and pay for a particular usage tier based on the number API calls over a fixed time period.

– Usage based: Pricing is determined by consuming units of measure, such as API calls. For example, a cloud storage company could charge per gigabyte of usage per month.

– Transaction fee: Pricing is dependent upon the value of the transaction.

– Freemium: In this model companies offer developers some of their APIs capabilities for free and then charge for additional functionality.

Developer gets paid:

– Revenue sharing: Developers receive small percentage of total revenue based on a business agreement with the provider.

– Affiliate: Developers receive scaling revenue (either percentage based, fixed price or tiered scale) based on extending partner platforms.

Source: https://developer.ibm.com/apiconnect/documentation/api-101/business-models-apis/

According to Hatvala (2016), the benefits of API include: wider reach of service, business process automation and increased internal agility. API providers may use API to foster open innovation (leveraging the creativity of third-party developers), to scale up business (speed up their product development), to reach new audiences and to improve internal IT architecture. Iyer and Subramaniam (2015b) found two main business benefits to offering an API: APIs can attract blockbuster complements and APIs are the windows to new ecosystems.

The MuleSoft (2018c) Connectivity Report explores ways to flesh out the benefits, as "APIs also unlock the value of internal data, making it easy for people throughout the business to consume data and applications in an easy and standardized way". The three main benefits of APIS according to the survey[24] are: increased productivity, innovation and employee engagement/collaboration. The 2019 survey provides a similar hierarchy of outputs (MuleSoft, 2019a, 2019b: p. 15). These three main benefits rank higher than cost reduction or revenue gross as a direct result, but nevertheless seems in line with what Benzell *et al.* (2017: p. 20) found. Box 4 shows, through the example of an insurance company, how APIs may enable businesses providing new ways to connect with customers.

Box 4. APIs Enable Businesses. The case of an insurance company.

An effective API can give existing and potential customers new reasons to interact with a business and connect with it on a personal level – and to share their experiences with others. As an example, MuleSoft takes the hypothetical case of a national auto insurance provider. Over the years, as part of its normal business operations and planning, it has assembled and maintained comprehensive, detailed and up-to-date data on the quality and condition of local roads all across the country. By making this previously internal data publicly accessible through an API, the company unleashes the creativity of developers and related businesses to devise new uses for the data.

Developers create apps that recommend driving routes based in part on road quality. Civic groups develop apps that empower citizens to band together and petition local officials for better funding of transit infrastructure. The insurance company may give potential customers a way to get rate quotes – whenever they want, and from wherever they happen to be – through Web and mobile apps. Simply exposing this previously isolated and hidden data through a public API has given the insurance company a powerful way to extend its reach to thousands of new customers – who now regularly connect with the company in a more personal, meaningful way.

An API strategy may allow a company the opportunity to improve customer engagement and creating new products and new channels that can be used in increasingly innovative ways.

Source: www.mulesoft.com/resources/api/connected-business-strategy

The same 2018[25] survey reveals significant financial benefits stemming from API adoption: " [...] a quarter of their organization's revenue is now generated from APIs and API-related implementations. More than a third (35 per cent) of respondents stated that over a quarter of their organization's revenue came from APIs" (MuleSoft, 2018b: p. 21).

For private companies, there are other ways to look at the impact of APIs on their economic performance. Benzell *et al.* (2017), using data for a sample of more than 120 firms that opened APIs, found that "firms adopting APIs see increases in sales, net income, market capitalization, and intangible assets" (Benzell *et al.*, 2017: p. 32). They use net income and operating profits to measure the short-term impact of APIs, market value and intangible assets for long term impact. However, they also stress that their regression analysis reveals the most significant relationships between "API adoption and market value." Although market value (or market cap)[26] can be a dubious indicator of the real economic value of a firm, this is coherent with the analysis offered by Benzell *et al.* as they link the use of APIs to the prediction of financial performance, as they put it "API adoption sends a signal to investors" (Benzell *et al.*, 2017: p. 20).

Finally, from a micro-economic viewpoint, some consultancies have been focusing on one API and tried to determine the costs of the creation of a single API and its value. For instance, Lutterop (2018) calculated that the additional costs for the creation of an API. Pearlman (2016) from MuleSoft offered a formula to calculate the estimated value of a specific API. Without going into any details, suffice to say that they both find that the cost of creation was modest (if not marginal) and that the consequent value may be significant. In other words, barriers to entry for developers seem low.

3.2 Application programming interfaces and apps: triggering the growth of the "App economy"[27]

As the cases of our sample of companies illustrate, but also of content companies (Netflix[28], music streaming companies such as Spotify[29]) illustrate, APIs are "under the hood" of an ecosystem, triggering the creation of "apps," and the growth of the "App economy[30]." This presumed impact is also a way to track some of the positive externalities generated by APIs, to assess some of the indirect benefits. Art (2016) stressed that apps such as iAlien and TweetDeck (mobile clients for Reddit and Twitter), only came into existence thanks to open APIs from the two sites. APIs appeared to have been key for the move to the mobile internet[31].

Indeed, mobile apps and SaaS providers rely heavily on APIs (Medrano, 2014): APIs are stepping stones for the creation of "apps." The big IT companies (Amazon, eBay...) treat APIs as the core of their business. Therefore, APIs are major enablers of what is called the "app" economy. The impressive growth of the "App" economy, has been enabled to a large extent by APIs that for some apps, especially consumer ones, provide the tool that enables user interaction with data from multiple applications.

Jones (2020) states that apps have become "one of the largest consumer ecosystems on the planet," with the global app economy expected to reach $6.3tn by 2021. Worldwide app downloads totalled 114.9 billion as of 2019 (30.6 billion on the App Store and 84.3 from Google Play) (Sensor Tower, 2019: p. 2). As of 2019, the number of apps available across app stores expanded to more than 6 million worldwide (Statista, 2020; AppAnnie, 2018: p. 9): with 2.57 million apps on Google Play and 1.84 million on the iOS App Store. Total

consumer spend through Google Play, the iOS App Store Consumer was expected to approach $90bn worldwide in 2019 (excluding third-party Android) (AppAnnie, 2019). Consumer spend only includes the money generated by iOS and Google Play in the form of paid apps, in-app purchases or in-app subscriptions. However, the revenue earned in the app economy is much larger and includes revenue flowing through third-party Android stores, m-commerce (e.g. ride-sharing, shopping) and in-app advertising. The same consultancy predicts that new apps will continue to be introduced at an exponential rate.

4. Looking for the application programming interfaces economy

4.1 The "API economy," a catch-all notion or a useful metaphor?

As acknowledged by a recent work on the "API economy": "There is hardly any mention of the API economy in research literature" (Moilanen *et al.*, 2019: p. 189). Most of the academic literature still stems from engineering department or business-management departments, not department of economics. Consultants would usually focus on the potential of business growth, on how to design an effective API strategy but not on the very economic dimension[32].

There is no consensus either on what it stands for; the terms being used vary from API Platform (Gawer and Cusumano, 2014; Gawer, 2014), to API ecosystem or "apps as platforms" in ever-wider ecosystems (apps "constellations"), integrating a broad range of services (with Tencent's WeChat being the pioneering model of "apps within an app"), but whatever the term used, it points in the same direction of a comprehensive multi-factor approach of extended relationships, some being monetized other not. Hatvalla notes that: "There is no established definition of API economy, but the term is usually understood to refer to increased economic significance of APIs" (Hatvala, 2016: p. 24). Besides, some of the standard metrics or indicators are hard to find[33]. The 2015 EC [European Commission (EC), 2015: p. 60] report stated about Open Data that "It is a challenge to identify economic indicators that are both stable over time and easy to measure when assessing the economic impact arising from the re-use of Open Data". This holds for APIs.

Medrano (2012), one of the early promoters of the "API economy," who considers that "APIs are a key growth driver for hundreds of companies across a wide range of industry sectors," is nevertheless careful about the scope of the transformation. He acknowledges that: "Still, despite the persuasiveness of the API promise, the majority of 'traditional' companies remain on the side-lines, perhaps daunted by what they see as an opportunity for a slightly hipper crowd." A view confirmed by Evans and Basole (2015). A view also shared by Iyengar *et al.* (2018) who found that the number of firms with mature API programs remains small. They also add that "most enterprises have failed to capture the value they initially envisioned from APIs."

Bonardi *et al.* (2016, p. 38) use "API Economy", as some kind of metaphor, "as a reference collaboration paradigm, because of its intrinsic potential in fostering innovation going beyond the traditional development of vertical solutions." In their "API Economy scenario," "APIs can be considered as the 'wholesale' version of a Web presence, allowing other parties to access and integrate company's data and resources into their public or private sites and applications." (Bonardi *et al.*, 2016: p. 32).

4.2 A brave new world indeed? "Distress" in the ecosystem

On the critical side, some papers highlight weak points in the API ecosystems and especially in the provider/developer relationships. McDonnell *et al.* (2013: p. 9) note that "Although client applications are heavily dependent on Android, developers seem hesitant to embrace unstable, fast-evolving APIs quickly." The study finds that "API updates are more defect prone than other types of changes in client code." According to the authors: "This slow adoption trend may pose various types of risks for client applications such as security vulnerability or poor performance."

They reveal that the American Civil Liberties Union (ACLU) filed complaints on spotty Android updates, "stating they could potentially harm users by letting hackers steal user data by utilizing security holes."

Espinha *et al.* (2014: p. 84) even speak of "the distress" caused by the imposition on Web API client developers. They consider that "developers using web APIs are forced to accompany the API providers in their software evolution tasks." Espinha *et al.* (2014: p. 93) also consider that Web APIs still fall short of an industry standard. By the same token, licensing, copyrightability and fair use of APIs have been issues as illustrated the conflict between Google and Oracle. After the acquisition of Android in 2005, as licensing negotiations with Sun failed, Google then copied lines that were part of an API from Sun's Java SE program. Soon after acquiring Sun, as of 2010, Oracle brought a lawsuit claiming that Google's use of Sun's Java API infringed both its copyright and patents. The patent infringement was discarded. Eventually the US Supreme court concluded, in April 2021, "that Google's copying of the API to reimplement a user interface, taking only what was needed to allow users to put their accrued talents to work in a new and transformative program, constituted a fair use of that material as a matter of law" (US Supreme Court, 2021: p. 4), that "fair use" of that material was freeing Google from copyright liability.

Besides, the dominance of the IT companies listed above is more and more perceived as an issue. Bodle (2011), notes critically that Open APIs "also provide a means for companies like Facebook to achieve market dominance, as well as undermine privacy, data security, contextual integrity, user autonomy and freedom." Facebook's Open APIs have established conditions for online sharing and participating that undermine privacy, data security, transparency and user autonomy. Bodle (2011: p. 335) states that "Facebook utilizes interoperability as a way to achieve market dominance and user dependency, while enforcing norms of sharing that do not maintain contextual integrity and collapse public and private distinctions that establish a power imbalance between Facebook, its partners, and its users." Botta and Wiedemann (2019: p. 472) also consider Facebook's terms of service unfair.

A recent study from ProgrammableWeb confirmed the lock-in effect and how difficult it is to export data out of the Facebook's ecosystem (Berlind, 2019). Barriers to entry for developers may be low but once available from a large company such as Facebook, switching costs may be high. Therefore, as of 2019, the German Federal Competition Authority sanctioned Facebook for abusing its dominant position[34]. As stressed by Botta and Wiedemann (2019: p. 478), this "recent Facebook decision represents the first case of exploitative abuse sanctioned in Europe in digital markets." As noted by the 2020 UK CMA report (Competition and Markets Authority, 2020: p. 140): "Facebook is able to worsen smaller competitors' offerings to consumers by degrading the functionalities enabled through interoperability or removing the service entirely[35]." Indeed, it was held that the firm "is using APIs technology to merge 'user data obtained from third party sources' (so-called off-Facebook data26) 'with data from the Facebook user's account, even if the user has blocked web tracking in his browser or device settings'" (Di Porto and Ghidini, 2018).

In the backdrop of Open Data Policies, some authors found specific issues in the case of public entities. Hatvala (2016: p. 29) quotes a 2016 study from Lee *et al.*, of apps produced as a result of open data application competitions such as Open Finland Challenge, which found out "that first-generation apps did not produce measurable civic benefit," and identified multiple problems associated with these apps. These negative outputs were taken into account when new second generation apps were planned and the relationships between developers and public organizations seem to have improved over time. Lee *et al.* (2016: p. 15) concentrating on the issue of "Open Data," found that: coordination seems to have been an issue, application discovery remained problematic and that developers were forced to find and examine many fragmented websites. The authors view effective incentive management for all types of actors in such heterogeneous ecosystems as more complex than in traditional markets. There is "an inherent tension between collaboration and competition" in these complex and diverse ecosystems. They point to "a need for trust in the stability, continuity and availability of open data streams and APIs that is not always secure in politically turbulent municipalities."

For private companies, Aitamurto and Lewis (2012) examine the relative value of open innovation principles for digital media, exemplified by the emergence of Open APIs at four news organizations. They note that “as yet, Open APIs have not been transformational to news organizations. These Open APIs have not resulted in major commercial success” (Aitamurto and Lewis, 2012: p. 329). They remain very cautious about the value derived from Open APIs deployment, as “it will not solve the myriad problems facing news organizations.” They deem the influence of open innovation processes to be relatively small, although still evolving with the continuing expansion of Open API offerings.

5. Conclusion

Beyond the impressive growth of the “apps economy” and its strong link with APIs “under the hood,” the so-called “emerging API economy” still stands on the “hype” side and is not clearly substantiated. The notion remains a bit vague. This is not surprising considering the (still) recent growth of most APIs. It may still be too early to come up with a full description of the market and its structure. Part of this difficulty may be linked to the fact that APIs are not final products/services but necessary ingredients for the production of a final service, a “wholesale” version of access to the Web. Such ingredients of the supply chain are more difficult to track in a digital economy. The value added is hard to track back.

Besides, as noted the number of firms with mature API programs remains small. The field is dominated by new digital platforms companies and the presence of traditional firms is weak. Exporting these technologies in other kind of organizations may be a difficult task and not deliver all the expected benefits, as the case of news organization may indicate, even if it is a single example. This may constitute a barrier for a further more even deployment of APIs especially in a context of new disruptive technologies such as machine learning, AI and 5 G[36]. Furthermore, it still appears difficult for most enterprises to fully capture the value they initially envisioned from APIs. This is not surprising either, a similar situation was found for Big Data (De Prato and Simon, 2015) and AI (Simon, 2019). The cases of the companies of our sample of digital natives cannot be held as representative neither give clues for the way to anticipate further deployment and growth in other sectors.

There are some issues and challenges ahead for the deployment of all kind of APIs as follows (private and public):

- There is an uneven development across industries (traditional firms are less active than digital natives) and countries (Silicon Valley is leading).
- The domination of IT companies (leaders and pioneers of APIs) raises issue of competition and at some point, may prevent rather than foster innovation. The Facebook decision is an attempt to deal with some of these issues. The UK CMA report (Competition and Markets Authority, 2020: p. 21) recommends setting up a pro-competition ex ante regulatory regime.
- Open Data policies create a fertile environment but may have to be complemented by some regulatory interventions.
- There are conflicts and tensions that cannot be underestimated with developers working under asymmetric conditions.
- Further complexity in the management of public APIs within complex heterogeneous public ecosystem is to be expected.

Nevertheless, to close with a positive note, it may be still useful to use the wording “API Economy” as some kind of metaphor to account for some of these interactions, to assess the role of APIs in the backdrop of the history of services computing. Some kind of “breadcrumb trail.”

Notes

1. Dictionary of Computer Science – Oxford Quick Reference, 2016. For a comprehensive review of the definition of APIs, see Vaccari *et al.* (2020: pp. 18–21).
2. Vaccari *et al.* (2020: p.18) note that: "This notion probably first appeared in 1968".
3. We will use "public" API as a shorthand for "digital government API" whenever there is no risk of confusion with private businesses that are publicly listed.
4. ProgrammableWeb is the best known and globally recognized API directory. www.programmableweb.com
5. Public in the sense of publicly open, as opposed to "private," but not to government/public APIs.
6. See the section on "going public."
7. A company that provides text-, voice-, and picture-messaging capability that can be embedded into any application: www.twilio.com/company
8. This section is based on an analysis of the annual reports of the following companies: Alibaba, Alphabet-Google, Amazon, Apple, Baidu, Facebook and Tencent. These companies do not disclose their contractual relationships with suppliers; however, they usually publish the kind of arrangements they offer to developers (provision of SDK). Besides, down payments to these suppliers may be available in their annual reports (Facebook disclosed the amount of revenues received from the game company Zynga in 2013). One can find a very comprehensive description of some leading firms in (Gartner 2018).
9. In all these cases, developers and third parties involved in apps and content are treated such as regular customers. It does not involve any privileged relationships beyond usual commercial trusted relationships.
10. The company provides SDK for iOS, Android and Unity. By using these tools for sharing, messaging, invites, requests and mobile application ads, developers have a number of ways to drive application discovery and user engagement. Finally, it helps developers monetize their Web applications by providing an online payments infrastructure that enables developers to receive payments.
11. As of 2007, the following year Facebook overtook Myspace.
12. MuleSoft was founded in 2006 and acquired by Salesforce in 2018 for $6.5bn. The company provides a software platform that enables organizations to easily build application networks using APIs. www.mulesoft.com/about
13. One can find a presentation of the initiatives of the government of Singapore in (Lee 2016, 2018).
14. Examples of public sector information are "geographical information, statistics, weather data, data from publicly funded research projects and digitized books from libraries" (EC, 2019).
15. Part of the EC ISA2 program, 2017–2018. https://ec.europa.eu/isa2/isa2_en
16. Amsterdam City Data, Cable & Pipe Information Portal (KLIP), Denmark Addresses Web API (DAWA), Estonia X-Road, Future Internetware (FIWARE), Madrid Mobility Lab, Team Digitale. Some of these cases are further documented in Vaccari *et al.* (2020: p. 55).
17. A national database that includes more than 25 million postal addresses and their geolocation in France. The database is a partnership between: The National Institute for Geographic and Forest Information (IGN), La Poste (state-owned postal service company); OpenStreetMap France (French association); and Etalab (French Open Data Taskforce). See: "3.2.1. Government application programming interface cases."
18. data.gouv.fr/api
19. See: "3.2.1. Government application programming interface cases," pp. 43–48.
20. See also (Cloud Elements 2019) for the distribution of APIs across 50 countries.
21. They offer through a visualization of the current API economy that is much more difficult to read than Figure 2.
22. Sandoval (2018) reviews seven types of API Business Models.
23. Traditionally, marketing fell into two categories; business to business (B2B) and business to consumer (B2C).
24. The survey was commissioned by MuleSoft and independently carried out by Vanson Bourne. The total sample size was 650 IT decision-makers working at organizations with 1,000+ employees: US 250, UK 100, Germany 75, Netherlands 50, Australia 50, Singapore 50 and China. Fieldwork was undertaken in November/December 2017.

25. Same figure in the 2019 survey.

26. Market capitalization (also known as market value) is the share price times the number of shares outstanding (including their several classes) for listed domestic companies.

27. "App economy refers to the range of economic activity surrounding mobile applications. The app economy encompasses the sale of apps, ad revenue or public relations generated by free apps, and the hardware devices on which apps are designed to run." Source: www.techopedia.com/definition/28141/app-economy

28. The primary focus of Netflix's API program is to support the myriad devices used by their million members to stream TV shows and movies from Netflix. The company closed down its public API in 2014.

29. (Ng 2019).

30. "App economy refers to the range of economic activity surrounding mobile applications. The app economy encompasses the sale of apps, ad revenue or public relations generated by free apps, and the hardware devices on which apps are designed to run." Source: www.techopedia.com/definition/28141/app-economy

31. For the mobile wave see (Simon 2016a, 2016b).

32. See, for instance, (Brown 2019).

33. Such as market size and value-added as a percentage of GDP, the number of jobs created, cost savings for the public sector, efficiency gains (a more qualitative one although measurable) or productivity gains.

34. Facebook decision. The decision was made public on 29 March 2019. It is available in English www.bundeskartellamt.de/SharedDocs/Entscheidung/EN/Entscheidungen/Missbrauchsaufsicht/2019/B6-22-16.pdf?__blob=publicationFile&v=5

35. "Deprecation' of the APIs": The term 'deprecation' is used by Facebook to refer to the removal of software, technology or APIs, as part of implementing updates to its platform (CMA, 2020: p. 140).

36. Not to mention security issues. As stressed by Vaccari *et al.* (2020: p. 53): "cybersecurity is considered as the major threat in both actual and potential API strategies."

37. SOAP: simple object access protocol. Later, SOA or Remote Procedure Call (RPC) evolved into more Web-friendly technologies, such as Representational State Transfer (REST). While SOA was largely confined to the enterprise and focused on interoperability, REST APIs brought the power of reuse within reach of individual developers at the internet-scale through consumability. Source: (Vukovic *et al.* 2016).

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Corresponding author

Jean Paul Simon can be contacted at: jpsmultimedia@hotmail.com